PREPARED BY:
WESTCO STORAGE LTD.

REFRIGERATION WASTE HEAT RECOVERY

Westco Storage Ltd.

Portage la Prairie, Manitoba

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MANITOBA/CANADA CONSERVATION AND RENEWABLE ENERGY DEMONSTRATION AGREEMENT

The availability of secure and affordable energy supplies is a subject of national concern. It is an accepted fact that our primary energy sources - oil and natural gas - are becoming less accessible and more costly. However, Canada is well-endowed with non-renewable and alternative resources that can provide a bridge into the future.

To this end, the governments of Manitoba and Canada have entered into a Conservation and Renewable Energy Demonstration Agreement which was signed May 9, 1980 and terminates March 31, 1984. The Agreement is dedicated to the development and demonstration of conservation and renewable energy technologies. Equally cost-shared by the provincial and federal governments, the program has a total budget of $18-million.

The objectives of CREDA are:

- To develop and demonstrate promising new technologies, which, when widely adopted, will exploit renewable resources, conserve energy and/or use energy more efficiently.
- To develop broad public awareness of the potential of renewable energy and conservation technology.
- To provide opportunities for the commercial application of the technologies within Manitoba.
- To create economic spin-off benefits for manufacturing, industry and commerce.
- To create employment in new or existing energy-related industries.

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1. SUMMARY

Westco Storage Ltd. of Portage la Prairie, Manitoba, received joint funding for this project from Canada and Manitoba, under the Federal/Provincial Conservation and Renewable Energy Demonstration Agreement (CREDA).

The purposes of the project were:

- to illustrate the effective incorporation of special insulation and building techniques for conserving energy in a new commercial cold storage warehouse.

- to demonstrate energy efficient heat reclamation systems, designed to recover and utilize waste heat from the plant refrigeration system.

Heat is reclaimed from the refrigeration plant ammonia compressors by means of an ammonia to water heat exchanger. The hot water is circulated to unit heaters for heating the dry storage and loading dock areas. In a separate system, a glycol solution, also heated by exchange with hot ammonia, is circulated under the floor of the freezer to prevent permafrost formation. These systems, together with additional wall and ceiling insulation, insulated overhead doors and other measures designed to reduce air leakage, have resulted in significantly lower energy costs for the facility.

While it is difficult to evaluate the financial results of individual steps taken to conserve energy, it would appear that annual total space heating costs are approximately $11,500 lower due to the additional insulation and heat recovery programs. Significant electrical savings were also achieved by decreasing the on-time operation of the freezer plant. While these savings are partially attributable to economics of scale it is believed that the improved vapour barrier and insulation used in the freezer have made a major contribution.

Energy costs in the new facility, for a recent twelve month period, amounted to 37.6 cents per cubic meter, which is well below the $1.589 per cubic meter average experienced in Westco's previous facility.

The reductions in space heating and refrigeration plant energy costs should yield a simple payback of about five years on the additional costs of the conservation measures.

RÉSUMÉ

Les fonds que Westco Storage Ltd., de Portage-la-Prairie au Manitoba, a reçu pour ce projet, ont été versés par les gouvernements du Canada et du Manitoba, dans le cadre de l'entente fédérale-provinciale sur la démonstration des énergies renouvelables et des économies d'énergie.

Les buts du projet étaient de:

* présenter des méthodes efficaces d'application d'isolants spéciaux et des techniques de construction particulières permettant de conserver l'énergie dans un nouvel entrepot frigorifique commercial;

* faire la démonstration de systèmes efficaces de récupération de la chaleur, conçus pour recycler la chaleur provenant du système de réfrigération de l'entrepot.

La chaleur récupérée par l'échangeur de chaleur provient des compresseurs à ammoniac de l'entrepot et est transférée de l'ammoniac à l'eau. L'eau chaude est ensuite acheminée vers différents appareils de chauffage, situés dans la salle d'entreposage à sec et près du quai de chargement. Dans un second système d'échange de chaleur, une solution de glycol, également réchauffée par échange avec l'ammoniac, circule sous le sol du surgélateur afin d'empêcher la formation de permafrost. Ces deux systèmes, alliés à l'isolement supplémentaire des murs, plafonds et portes basculantes ainsi qu'à d'autres mesures permettant de réduire l'infiltration d'air, font considérablement diminuer la quantité d'énergie utilisée par l'entreprise.

Bien qu'il soit difficile d'évaluer les implications financières de chacune des améliorations, il semblerait que, grâce au programme de récupération de la chaleur et à l'amélioration de l'isolation, le coût total du chauffage ait baissé d'environ 11 500$. D'importantes économies ont aussi été réalisées sur l'électricité, puisque la période de fonctionnement du surgélateur a été réduite. Même si cette économie peut être attribuée en partie à la grandeur de l'entreprise, nous croyons que l'amélioration des pare-vapeur et des isolants installés dans le surgélateur y a beaucoup contribué.

Les dépenses relatives a l'énergie dans le nouvel entrepot s'élevaient récemment à 37,6 cents par mètre cube pour une période de 12 mois, ce qui est bien plus économique que le 1,589 dollars que Westco devait débourser par mètre cube dans son ancien entrepot

La réduction des coûts de chauffage et de réfrigération de l'entreprise devrait permettre de rembourser en 5 ans les dépenses occasionnées par les améliorations.

2. BACKGROUND

Westco Storage Ltd. is located in Portage la Prairie, Manitoba, a community of 13,000 inhabitants. The City is situated on the main lines of both the CNR and CPR and is serviced by both the Trans Canada and Yellowhead Highways. Temperatures in the area range from a low in the winter of -40°C to a high in the summer of +40°C. The Portage la Prairie climate provides an excellent season for vegetable growers, who provide the basis for many of the region's industries. It is these industries that are the primary users of Westco Storage Ltd.

3. PROJECT MOTIVATION

The new facility became necessary when the original Westco building and its contents were destroyed by fire in 1980. In the last year of operation prior to the fire the energy consumption and costs in the old facility were as follows:

	kW.h	$
Natural Gas	617,000	5,533
Hydro	1,550,000	39,690
	2,167,000	45,223

Recognizing that the new facility would be more than three times the cubic capacity of the original one, and allowing that future expansion was a real possibility, Westco looked for ways to lower the unit operating costs, especially the energy costs. As part of an effort to reduce the total energy consumption of the building and, in particular, to reduce or eliminate consumption of non-renewable energy resources, Westco retained Fleming Pedlar Limited of Winnipeg to design and install an energy recovery system, operated totally by electricity.

4. FACILITY

The initial phase of the new facility, completed in 1981, was 12,300 square meters (132,500 square feet) in size, while the second phase, completed in 1982, was an additional 3,950 square meters (41,500 square feet).

Individual areas in the building are (phase two complete):

	Design Temperature (°C)	Cubic Capacity (cubic meters)
Freezer	-20.5	91,180
Cooler	2.8	2,831
Heated Storage	16.7	28,883
Loading dock	10.0	4,520
Office and other	21.1	2,265

The foundation for the entire facility is slab on grade. The perimeter grade beam is insulated with R-8 rigid polystyrene foam insulation. The walls of the heated storage and loading docks are pre-finished metal cladding with R-21 of fibre glass batting for insulation. The roof over these areas is also pre-finished metal with R-30 of fibre glass batting for insulation. The interior finish of all fibre glass batting is a heavy-duty vinyl scrim facing which serves as the air vapour barrier.

After start-up, additional measures were incorporated to reduce air infiltration. Plastic strip curtains were installed in freezer door openings to reduce moisture and warm air flow into the freezer, and air inflated door seals were installed around exterior truck doors to reduce the flow of cold air into the heated areas of the building.

The walls of the freezer and cooler are urethane sandwich panels produced by Coldstream Products of Canada Ltd. The panels, which have R-38 of urethane insulation are 4-1/8" thick and are finished on both sides by 28 gauge pre-finished metal which serves as an excellent air vapour barrier. The roof of the cooler is the same as the heated storage roof, while the roof of the freezer is metal decking over which was placed six inches of foamed-in-place urethane insulation, having an R value of 45. The vapour barrier of 42 mil. of rubber coating was applied in three coats on top of the urethane insulation.

A rail shelter was built on the north side of the building to buffer prevailing north and north-west winds encountered during the heating season.

5. EQUIPMENT

5.1 General

The refrigeration systems uses two rotary screw compressor packages rated 150 HP and 200 HP, both manufactured by FES of York, Pennsylvania. The two compressors were the first in Canada to be installed with FES Micro Processor control panels. These panels make monitoring and control of the system's operating conditions much easier. All pertinent readings are available in a digital readout form on the panel. It is expected that electronic control will pay off in reduced maintenance and energy consumption. FES also supplied the liquid ammonia recirculating package and the evaporative condenser. Imeco evaporators are used in the freezers.

Lighting throughout the storage areas is high pressure sodium. Fluorescent lighting is used in office areas.

5.2 Heat Recovery Systems and Building Heating

Recovered heat is utilized in two separate and distinct areas (see Figure 1).

5.2.1. Drygoods Storage and Loading Dock Heating

In typical cold storage operations, the heat extracted from the cold rooms by the refrigerant is dumped outdoors through the use of outdoor condensers.

In Westco's application, heat is reclaimed from the hot compressed ammonia refrigerant by transfer to a recirculating hot water heating system. The water, heated in an ammonia-to-water heat exchanger, is pumped through a loop that services the loading dock and dry storage areas of the warehouse. Thermostatically controlled ITT-Grinnel suspended hot water unit heaters extract the heat for space heating. A return line to the heat exchanger completes the loop. Make up water is automatically supplied as required from a sandpoint well.

When the refrigeration plant is not running and space heating is required, a standby 180 kW electric boiler reheats the water.

5.2.2. Underfloor Heating

A separate system also reclaims heat from hot ammonia by means of a second heat exchanger.

In this system a glycol solution is heated and circulated through plastic pipes installed beneath the freezer room floor insulation. This is done to maintain the subsoil at above freezing temperatures, thereby preventing the development of permafrost which might cause heaving of the floor. This heat is required throughout the year.

The underfloor pipes are continuous and are connected in parallel, running from a feed header pipe to a second header which returns to the heat exchanger. The underfloor pipes are installed at one foot centres and can be isolated for service, if necessary, with minimal effect on the remaining system.

A pre-set thermostat installed in the subsoil controls the operation of the glycol pump. However, ammonia passes through the heat exchanger continuously to maintain a charge of hot glycol.

5.2.3. Other Heating Equipment

To prevent heat stratification, slow moving fans with variable speed controls were installed at a high level throughout the heated areas of the warehouse.

Separate from the main mechanical system, the office is serviced with a combination 13 kW. heating and 5 ton cooling roof top unit and supplementary baseboard heating. For simplification, the office and its heating systems were not included in this analysis. The heat gain in the warehouse from office heating is considered minimal.

5.2.4. Heat Venting

During certain operational periods, such as summer, refrigeration system heat is produced in excess to that required for building area and subfloor heating. At these times the hot refrigerant is automatically diverted through the outside evaporative condenser, where the heat is dumped to the air. The condenser is cooled with water from a second sandpoint well.

5.2.5 Other Operational Details

Management initiated several energy saving technical changes subsequent to start up. Most noteworthy of these were the following:

a. The stand-by boiler was interlocked with the refrigeration compressors so that it could only operate if neither compressors were operating.

b. Ammonia recirculating pumps were interlocked with the compressors to shut off when the compressors were off.

c. Evaporator fan motors in the freezer were interlocked with thermostats controlling solenoid valves so that when valves closed, motors stopped as well, thus reducing internal load.

d. Two exhaust fans were installed in the mechanical room. One continuously exhausts heat into the loading dock in winter. The other exhausts heat outside in summer. Fans are interlocked to an ammonia sensor so that if ammonia is detected, it is exhausted outside. Fans are thermostatically controlled.

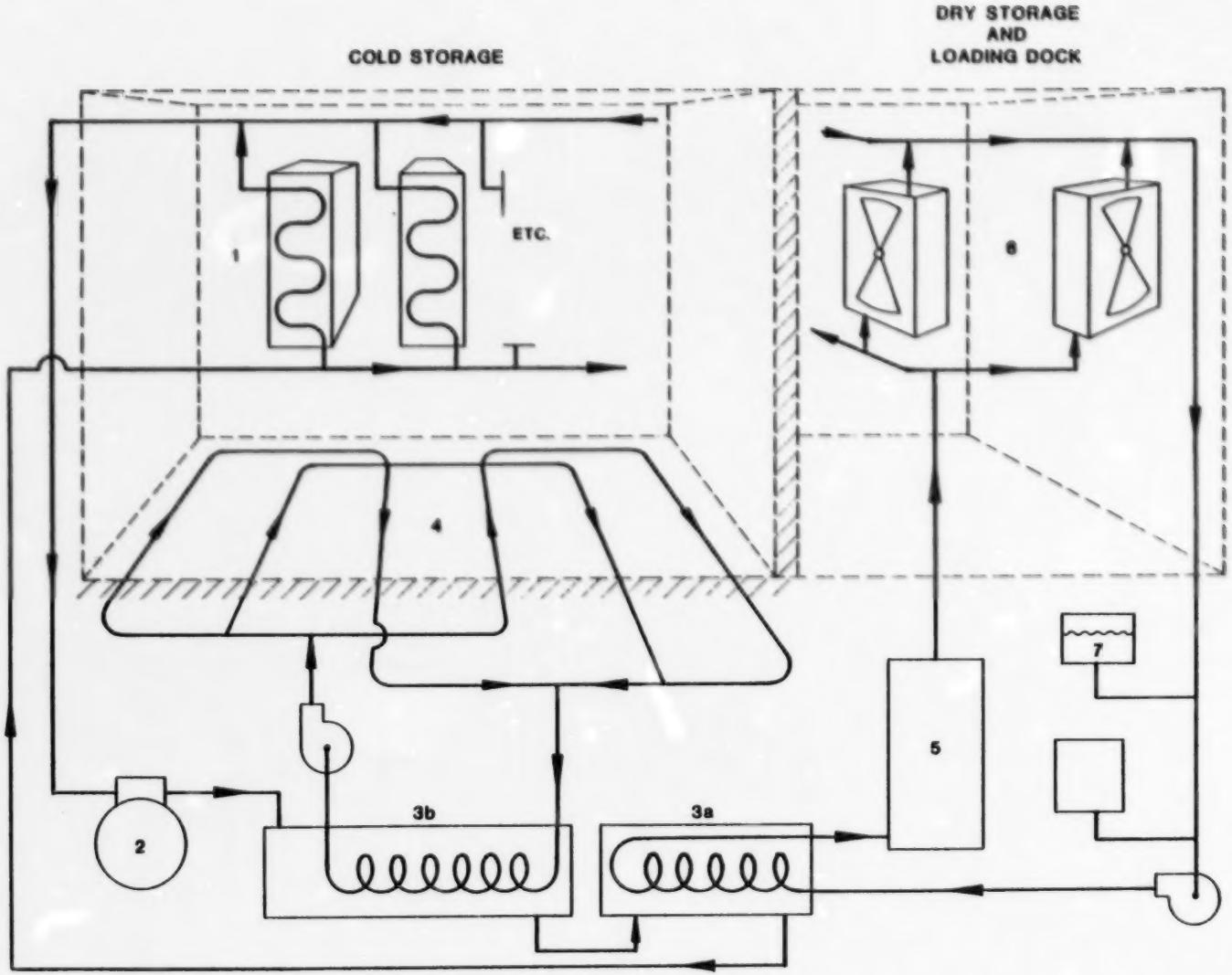


FIGURE 1 - SCHEMATIC DIAGRAM OF THE WESTCO HEAT RECOVERY SYSTEMS

1. EVAPORATIVE COOLERS IN FREEZER AND COLD ROOMS
2. AMMONIA REFRIGERANT COMPRESSORS
3 a). AMMONIA-TO-WATER HEAT EXCHANGER
   b). AMMONIA-TO-GLYCOL HEAT EXCHANGER
4. UNDERFLOOR HEATING (GLYCOL SOLUTION)
5. STANDBY ELECTRIC BOILER
6. HOT WATER UNIT HEATERS
7. EXPANSION AND WATER TREATMENT TANKS

6. PROJECT COSTS

The cost of the heating system and extra insulation were as follows:

Loading dock and storage heating	50,990
Subfloor heating	39,075
Electrical (estimated)	9,935
Additional roof insulation from R-20 to R-30	15,375
Additional wall insulation from R-12 to R-20	5,200
Premium for Coldstream panel wall system	34,725
	$155,300

The total cost of an alternative system, using suspended natural gas unit heaters for heating and electrical cables for the underfloor, was estimated to be $47,000. The premium paid was therefore a total of $108,300.

7. FINANCIAL RESULTS

Included in the appendices is an energy audit computer analysis of the facility which, under the assumptions made, indicates the following savings of heating costs could be achieved (See Appendix for more detail):

	Annual Savings	at a	Capital Cost of
Increased roof insulation	$ 965		$ 15,375
Increased wall insulation	979		5,200
Heat recovery system	9,556		53,000
	$11,500		$ 73,575

Energy savings have also been realized from the reduction of cooling requirements, due in major part to the increased insulation and sealing in the cold rooms. It has proven difficult to break out the actual savings attributable to these particular energy conserving measures, since economy of scale has some effect in the new facility. The facility previously operated by Westco Storage Ltd., which was approximately one-third the cubic capacity of the new one, had annual energy costs for cooling of $1.589 per cubic meter. The new facility had a cooling cost of $.376 per cubic meter for the twelve months ended January, 1983. It is Westco's opinion that while economies of scale certainly were achieved, energy related design efficiencies contributed significantly to the saving.

The company expects that payback will be less than five years for the total project.

8. MANAGEMENT OBSERVATIONS AND SUGGESTIONS

8.1 The typical discharge temperature of the rotary screw compressor is approximately 46°C (115°F). This would be at least 28°C (50°F) higher with reciprocating compressors. Consequently, systems not large enough to require rotary screw compressors would have greater heat transfer potential; this type of recovery should be economical for smaller operations. Heat transfer equipment could be reduced in size, reducing the effect of economy of scale.

8.2 Different compressor capacities were specified and installed; the Model 140 compressor has a 150 HP motor, while the 180 has a 200 HP motor. It was thought that varying loads could result in the smaller unit running at less cost. In fact, the units draw comparable power under comparable operating conditions. As a result, it may have been better, for only a small premium, to have had the reserve of two 200 HP compressors.

8.3 The vapour barrier provided by the Coldstream sandwich wall panel is very effective. In the previous facility, evaporators were defrosted three times daily for forty-five minutes. In this facility, defrosts are twice per week for thirty minutes, and are regulated by a seven-day time clock.

8.4 The only purchased energy is electricity. Electricity is considered to be 100% efficient compared to an estimated 65% seasonal efficiecy of natural gas. There are no gas related problems such as stack heat losses and stack emmissions.

8.5 The rail shelter, while not heated, is very practical. It provides excellent shelter from wind, thereby reducing air changes in the building.

8.6 Because the facility has low heat loss/gain properties, sustained power failures can be tolerated without adversely affecting the products being stored.

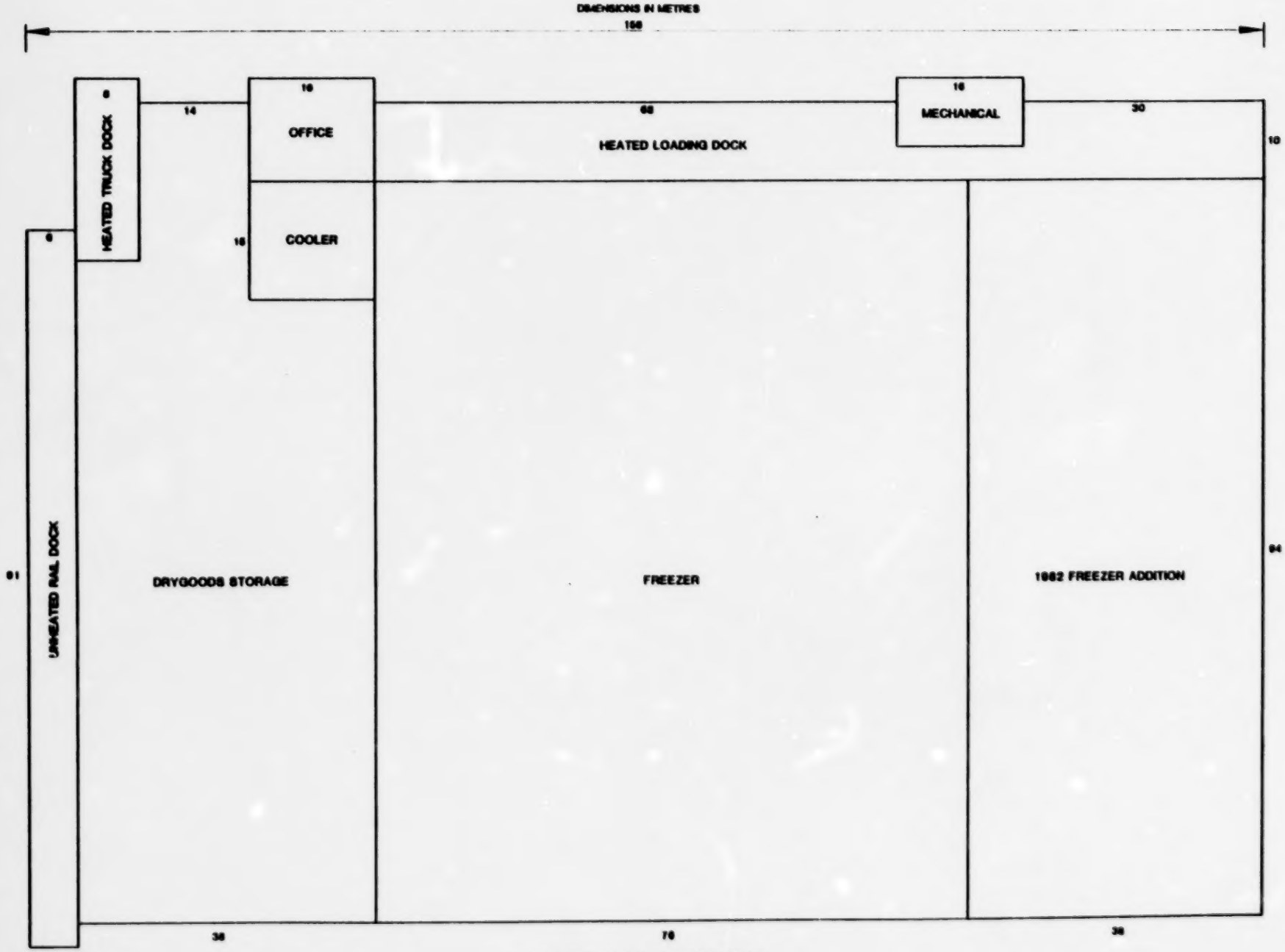
9. ECONOMIC SUMMARY OF CONSERVATION FEATURES

		SAVINGS	
		KW.h/year	$/year
1.	Additional roof insulation	56,557	965
2.	Additional wall insuation	40,204	687
3.	Additional freezer and cooler insulation	17,129[A]	292[A]
4.	Heat recovery	510,446	8,708
5.	Electric Boiler	31,528	848
		$655,864	$11,500

A. Savings indicated are only for reduction in space heating requirements for adjoining areas. Additional savings for reduction in refrigeration requirements due to insulation were not calculated in the computer program and have not been estimated.

APPENDIX A

FLOOR PLAN



FLOOR PLAN OF BUILDING

APPENDIX B

ENERGY AUDIT COMPUTER

ANALYSIS OF WESTCO FACILITY

Appendix B

ENERGY AUDIT COMPUTER MODELING OF FACILITY

A computer analysis of the Westco facility was run in order to estimate a breakdown of the savings attributable to some of the individual energy saving measures.

An Ener$ave interactive computer model developed for N.E.A.P., the National Energy Audit Program (Energy Bus) was used.

The procedure was to first model the Westco facility as a "typical" or baseline warehouse. The actual dimensions and operating parameters for Westco were input, along with typical storage warehouse insulation levels and natural gas heating of the warehouse.

Various upgrades, as actually incorporated into the Westco facility, were then "added" to the base warehouse and the savings calculated by the interactive model.

The following upgrades were modelled:

1. Increased roof insulation from R-20 to R-30.

2. Increased exterior wall insulation from R-12 to R-20.

3. Increased interior freezer and cooler wall insulation from R-28 to R-38.

4. Substitution of natural gas unit heaters with hot water unit heaters utilizing heat recovery from the refrigeration condensers.

5. Substitution of natural gas unit heaters with an electric boiler to supply make-up heating when heat recovery from the refrigeration condensers is not sufficient.

Results

1. Increased roof insulation from R-20 tO R-30.
   Savings (Energy) = 56,557 kW.h/year
   Savings = $965/year

2. Increased exterior wall insulation from R-12 to R-20
   Savings (Energy) = 40,204 kW.h/year
   Savings = $687/year

3. Increased interior freezer and cooler walls from R-28 to R-38
   Savings (Energy) = 17,129 kW.h/year
   Savings = $292/year

4. Substitution of natural gas unit heaters with hot water unit heaters utilizing heat recovery from the refrigeration condensers:

Internal heat gain (IHG) = (total heat loss - stack losses x fraction of IHG)
= (766,012 - 250,046) x .10
= 51,597 kW.h/year

Unit heater consumption (after insulation improvements)
= Total heat loss - IHG
= 652,122 - 51,597
= 600,525 kW.h/year

Cost of natural gas = $\frac{\$5.00}{MCF} \times \frac{MCF}{293\ kW.h}$

= $0.01706/kW.h

Approximately 85% of natural gas consumption for unit heaters is displaced by "free" heat recovered from the refrigeration condensers, based on current operations.

Savings (Energy) = 600,525 x .85
= 510,446 kW.h/year
Savings = 510,446 x 0.01706
= $8,708/year

5. Substitution of natural gas unit heaters with an electric boiler to supply make-up heating when heat recovery from the refrigeration condensers is not sufficient:

Unit heater consumption (after insulation improvements)
= 600,525 x (1.00 - 0.85)
= 90,079 kW.h/year

Consumption savings will be equal to the difference in efficiency of electricity (100%) and natural gas (65%)

Savings (Energy) = 90,079 x (1.00 - 0.65)
= 31,528 kW.h/year

Since the electric boiler is inter-locked with the compressors which have a higher demand, the cost of electricity will equal the "run-out rate".

Cost of electricity (for boiler only, 1982 rates)
= $0.0112 x 1.05 (prov. tax)
= $0.01176
Savings = cost of natural gas - cost of electricity
= (90,079 x 0.01706) -
[(90,079 - 31,528) x 0.01176]
= $1,537 - $689
= $848/year

APPENDIX C

PHOTOGRAPHS

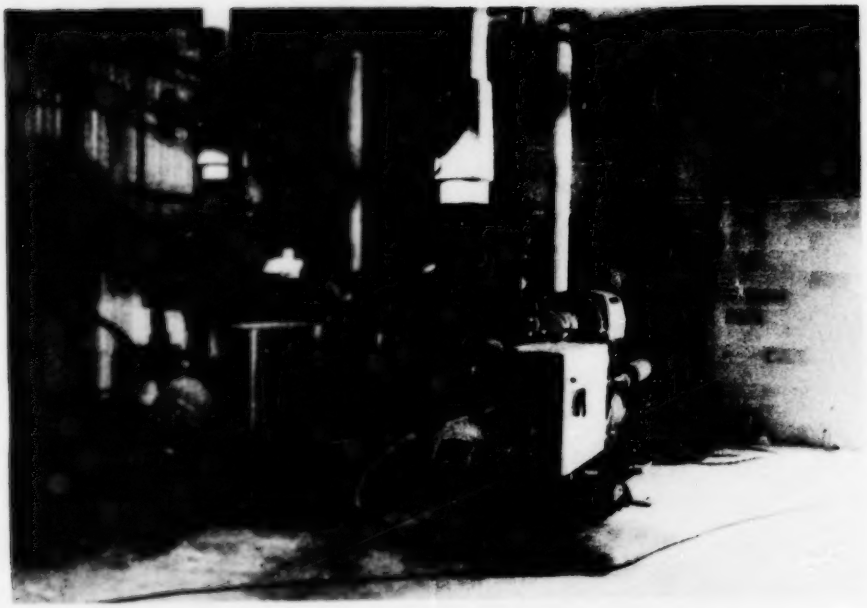


Fig. C 1 Refrigeration Plant Compressors and Controller Panels

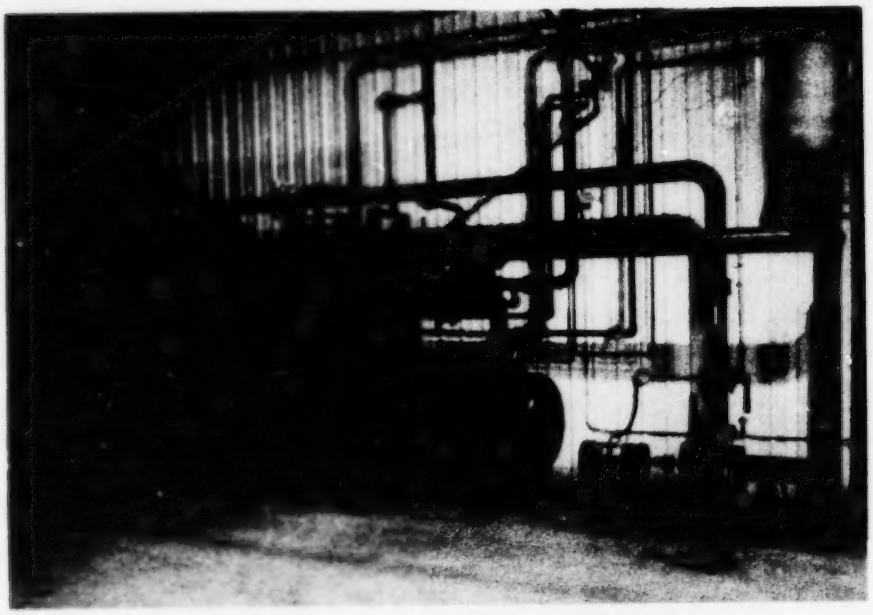


Fig. C 2 Heat Exchangers

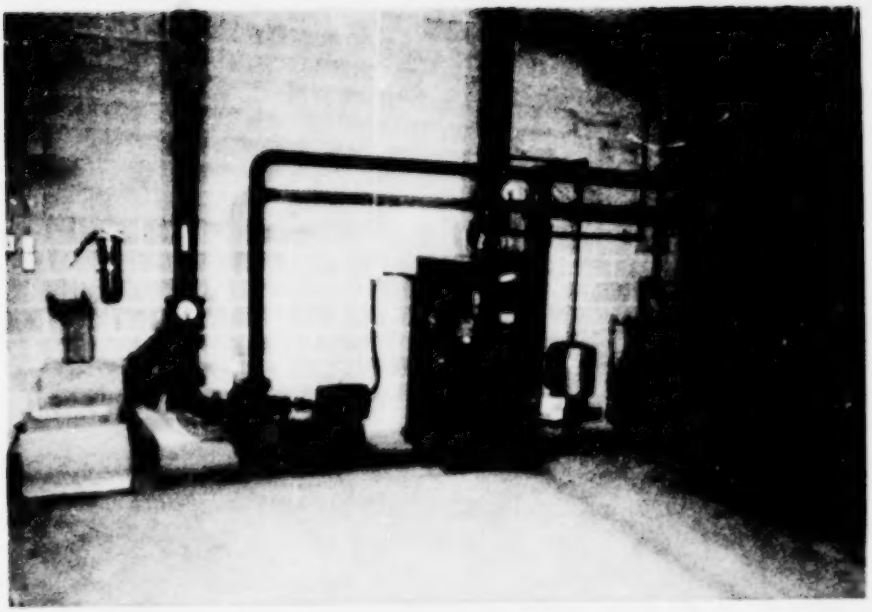


Fig. C 3 Standby Boiler

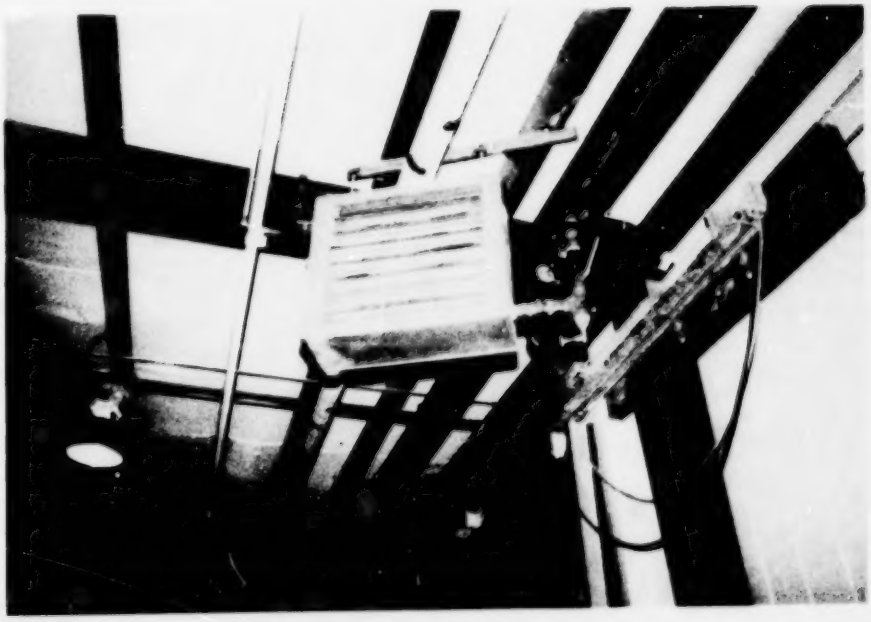


Fig. C 4 Loading Dock Area Unit Heater

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